

Type Theory and
The Semantics of Local Context
James Pustejovsky



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Questions Addressed in this Course

- **Encoding Context** through **Lexical Typing**
- **Architecture**: How does the grammar encode or license selection in language?
- **Expressiveness**: How much argument information can and should be selected/selectable?
- **Descriptiveness**: How does selection contribute to coverage of the data?
- **Qualia as Types**: Can qualia structure and event structure be adequately modeled as types directly?

COURSE OUTLINE

- **Monday**: Framing the Problem: Variations in Argument Selection
- **Tuesday**: Generative Typing: Types and Compositional Mechanisms
- **Wednesday**: Detailed Derivations using GL's Type Composition Logic
- **Thursday**: Describing Change and Changing Descriptions
- **Friday**: Applications of Generative Typing

Lecture 1. Framing the Problem

- Motivating Data
- Enriching Composition for More Explanatory Coverage
- Constraining Compositional Operations
- Encoding Context through Richer Typing

Assumptions

- Language meaning is **compositional**.
- **Compositionality** is a desirable property of a semantic model.
- Many linguistic phenomena appear **non-compositional**.
- **Generative Lexicon** exploits richer representations and rules to fix holes in the compositionality model.
- Richer representations involve **Lexical Decomposition**.
- Richer rules involve **Coercion, Subselection, Co-composition**.

- Mechanisms of Selection
 - **Strong Selection**: Selection of arguments through typing
 - **Weak Selection**: Patterns of **use**, stereotypical collocates
- Encoding **event structure** in the type language
- The Principles of **Decompositionality**

What is Selection?

1. What elements can **select**?
2. What is an **argument**?
3. What does it mean for a predicate to **select** an argument?
4. How does selection relate to **lexical decomposition**?

Verb Meaning: The Predicative Complex

1. Properties of the **participants**
2. Change (of **being, state, location, relation**)
3. **Causation** and **means**
4. **Manner** of the activity
5. **Temporal** and **Locational** constraints
6. **Intentionality** of the actor
7. **Instrumental** and **co-agentive** information
8. **Psychological state** of the participants

Property Abstraction

- (1) a. What kinds of properties are abstracted as **selectional restrictions**?
- b. Which of these aspects of meaning can be **abstracted** into **arguments** of the predicate?

Predicative Structure

- (1) a. **Verb:** V
- b. **Arguments:** x, y, z, ...

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- (2) a. **Body**: the predicate, with bound variables.
b. **Binding Environment (Args)**: the parameter list.

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$$\begin{array}{cc} \textit{Args} & \textit{Body} \\ \underbrace{\lambda x_i} & \underbrace{[\Phi]} \end{array}$$

Decomposition Strategies

1. ATOMIC PREDICATION:

Parameter structure mirrors syntactic behavior:

$$\lambda x_n \dots \lambda x_1 [\Phi]$$

2. PARAMETRIC DECOMPOSITION:

Parameter structure adds additional arguments for interpretation in the model, where $m > n$:

$$\lambda x_m \dots \lambda x_{n+1} \lambda x_n \dots \lambda x_1 [\Phi]$$

Decomposition Strategies

3. SIMPLE PREDICATIVE DECOMPOSITION:

P is defined as a complex expression of subpredicates over the parameter:

$$\lambda x[\Phi_1, \dots \Phi_k]$$

4. FULL PREDICATIVE DECOMPOSITION:

Parameter structure is enhanced, and P is defined as a complex of subpredicates:

$$\lambda x_m \dots \lambda x_{n+1} \lambda x_n \dots \lambda x_1[\Phi_1, \dots \Phi_k]$$

5. SUPRALEXICAL DECOMPOSITION:

Parameter structure is enriched through mechanism of additional operators, while P is enriched by a complex compositional operation:

$$\lambda f_{\sigma} \lambda x_1 [\mathcal{R}(f)(x_1)] (\lambda x [\Phi_1, \dots, \Phi_k])_{\sigma}$$

Atomic Predication

(2) Parameter structure mirrors the syntactic behavior:

$$\text{Verb}(\text{Arg}_1, \dots, \text{Arg}_n) \implies$$
$$\lambda x_n \dots \lambda x_1 [\Phi]$$

(3) a. $\lambda x [\text{die}(x)]$
b. The flower died.

(4) a. $\lambda y \lambda x [\text{hit}(x, y)]$
b. The car hit the wall.

Parametric Decomposition

- (5) Parameter structure adds additional arguments for interpretation in the model, where $m > n$:

$$\text{Verb}(\text{Arg}_1, \dots, \text{Arg}_n) \implies$$

$$\lambda x_m \dots \lambda x_{n+1} \lambda x_n \dots \lambda x_1 [\Phi]$$

- (6) a. $\lambda y \lambda x \lambda e [\text{kill}(e, x, y)]$: (Davidson, 1967)
b. The gardner killed the flower.

- (7) a. $\lambda z \lambda y \lambda x \lambda e [\text{go}(e, x, y, z)]$: (Hobbs, 1993)
b. Nicholas went to China.

Simple Predicative Decomposition

(8) P is defined as a complex expression of subpredicates over the parameter:

$$\text{Verb}(\text{Arg}_1) \implies$$

$$\lambda x[\Phi_1, \dots, \Phi_k]$$

(9) a. **die**: $\lambda x[\text{alive}(x) \wedge \text{Become}(\neg\text{alive}(x))]$

b. The flower died.

(10) **bachelor**:

$$\lambda x[\text{male}(x) \wedge \text{person}(x) \wedge \text{adult}(x) \wedge \neg\text{married}(x)]$$

Full Predicative Decomposition

(11) Parameter structure is enhanced, and P is defined as a complex of subpredicates:

$$\text{Verb}(\text{Arg}_1, \dots, \text{Arg}_n) \implies$$

$$\lambda x_m \dots \lambda x_{n+1} \lambda x_n \dots \lambda x_1 [\Phi_1, \dots, \Phi_k]$$

(12) a. **kill**:

$$\lambda y, x, e_1, e_2 [\text{act}(e_1, x, y) \wedge \neg \text{dead}(e_1, y) \wedge \text{dead}(e_2, x) \wedge e_1 < e_2]:$$

Supralexical Decomposition

$$\text{Verb}(\text{Arg}_1, \dots, \text{Arg}_n) \implies \lambda x_n \dots \lambda x_1 [\Phi]$$

$$v \implies \lambda f_\sigma \lambda x_1 [\mathcal{R}(f)(x_1)]$$

$$\implies \lambda f_\sigma \lambda x_1 [\mathcal{R}(f)(x_1)] (\lambda x [\Phi])_\sigma$$

$$\implies \lambda x_1 [\mathcal{R}([\Phi])(x_1)]$$

How is Decomposition related to Selection?

- The parameters that we give a relation are **values** of the tuple that satisfies the conditions under which this relation is judged true;
- They are also **determinants** on the members of this tuple.

How Arguments are Interpreted

(13)a. A rock fell.

$$\exists x \exists e [\text{fall}(e, x) \wedge \text{rock}(x)]$$

b. A rock died.

$$\exists x \exists e [\text{die}(e, x) \wedge \text{rock}(x)]$$

Predicate Abstraction

Consider the computation involved in interpreting these sentences:

- (14)a. The woman slept soundly.
- b. The soldier died in the street.
- c. . The child dreamt of Christmas.

The “Fail Early” Strategy of Selection

- (15) Arguments can be viewed as **pretests** for performing the action in the predicate.

- (16) If the **argument conditions** are not satisfied, the predicate does not get interpreted.

Argument Typing as Abstracting from the Predicate

- (17) Richer typing for arguments:
- i. Identifies specific predicates in the body of the expression that are **characteristic functions of an argument**;
 - ii. pulls this subset of predicates out of the body, and creates a *pretest* to the expression as a **restricted quantification over a domain of sorts**, denoted by that set of predicates.

Argument Typing as Abstracting from the Predicate

(18)

$$\lambda x_2 \lambda x_1 [\Phi_1, \dots, \overbrace{\Phi_{x_1}}^{\tau}, \dots, \overbrace{\Phi_{x_2}}^{\sigma}, \dots, \Phi_k]$$

σ and τ are sets of predicates describing properties of arguments to the predicate complex.

Predicate Abstractions Become Argument Types

(19)

$$\lambda x_2 : \sigma \lambda x_1 : \tau [\Phi_1, \dots, \Phi_k - \{\Phi_{x_1}, \Phi_{x_2}\}]$$

(20) σ and τ have now become **reified** as types on the arguments.

Generative Lexicon is a Typed Decomposition Formalism

- (21) a. A **Full Parametric Decomposition** Theory.
- b. Employs the computational efficiency of **pretest** argument typing.
- c. **Qualia Structure** provides a restricted calculus over decomposition potential .

Generative Lexicon

- Two classes of sortal constraints on a concept:
 - **Argument structure**
 - **Event structure**
- These bind into the **Qualia Structure**
- Compositional Rules invoke
 - **Type Selection**: Exact match of the type
 - **Type Accommodation**: The type is inherited
 - **Type Coercion**: Type selected must be satisfied

Argument and Body in Generative Lexicon

(22)

$$\begin{array}{c} \textit{Environ} \\ \overbrace{\lambda x_n \dots \lambda x_1 \quad \lambda e_m \dots \lambda e_1}^{\textit{AS} \quad \textit{ES}} \quad \overbrace{[Q_1 \wedge Q_2 \wedge Q_3 \wedge Q_4; C]}^{\textit{Body}} \end{array}$$

AS: Argument Structure

ES: Event Structure

Q_i : Qualia Structure

C: Constraints

Qualia Structure

Formal: the basic category which distinguishes it within a larger domain;

Constitutive: the relation between an object and its constituent parts;

Telic: its purpose and function;

Agentive: factors involved in its origin or “bringing it about”.

GL Logical Form

$$(23) \left[\begin{array}{l} \alpha \\ \text{ARGSTR} = \left[\begin{array}{l} \text{ARG1} = x \\ \dots \end{array} \right] \\ \text{EVENTSTR} = \left[\begin{array}{l} \text{EVENT1} = e_1 \\ \text{EVENT2} = e_2 \end{array} \right] \\ \text{QUALIA} = \left[\begin{array}{l} \text{CONST} = \text{what } x \text{ is made of} \\ \text{FORMAL} = \text{what } x \text{ is} \\ \text{TELIC} = e_2: \text{function of } x \\ \text{AGENTIVE} = e_1: \text{how } x \text{ came into being} \end{array} \right] \end{array} \right]$$

Encoding Context

- Local context modeled as **Strong Selection**.
- Words encode context as **typing information**;
- **Compositional rules** refer to these types:
- Types can be **selected**;
- Types can be **accommodated**.
- Types can be **exploited** (**coercion**).
- Types can be **introduced** (**coercion**).
- Composition can **license** new interpretations (**cocompose**).

Mechanisms of Selection refer to Type Level

Types of Expressions in Language (Level)

- **Natural Types**: atomic concepts of **FORMAL** and **CONST**;
- **Functional Types**: Adds concepts of **AGENTIVE** and of **TELIC**;
- **Complex Types**: Cartesian types formed from both Natural and Functional types.

Data Relating to Local Context in Language

- **Selectional Specificity:** The verb and nature of its argument
- **Verbal Polysemy:** The verb and the number of its arguments
- **Descriptions of Change:** The verb and how it selects for change

Syntactic Selection reflects Semantic Type

Count/Mass

- (24) a. {not much/all/lots of} *gold/water/dirt/sand*
b. {every/two/several} *chairs/girls/beaches*

Arity Constraints

- (25) a. Mary *arrived*.
b. John *hit* Mary.
c. Mary *gave* a book to John.

Animacy

- (26)a. The man / the rock fell.

b. The man / *the rock died.

(27)a. John forced / *convinced the door to open.

b. John forced / convinced the guest to leave.

Spatial Constraints

(28)a. John poured milk into / *on his coffee.

b. John poured water into / on the bowl.

(29)a. John crossed the lake / *the ladder.

b. John climbed *the ocean / the building.

Selecting for Manner

(30)a. The children behaved themselves.

b. Mary behaved *(well).

(31)a. John performed *(admirably).

b. John performed his piece yesterday.

Collections and Number

(32)a. The crowd / *the man assembled.

b. The audience / the fans dispersed into the streets.

(33)a. The professor counted his students.

b. He had ten graduates and five undergraduates.

c. He had only one.

Selectional Specificity in Natural Kinds

- (34) a. *Nominal Predication*: How the common noun behaves predicatively;
b. *Adjectival Predication*: How adjectives modifying the the common noun can be interpreted;
c. *Interpretation in Coercive Contexts*: How NPs with the common noun are interpreted in coercive environments.

- (35)a. Mary saw every *dog/pet*.
b. John visited a *man/doctor*.
c. *Birds/planes* can fly.

(36)a. a sick *dog/pet*

b. an American *man/doctor*

c. white *birds/planes*

(37)a. Otis is a dog.

b. Otis is a poodle.

b. Eno is a cat.

(38)a. ?Otis is a dog and and an animal.

b. !That is a dog and a cat.

c. Otis is a dog and therefore an animal.

(39)a. !This box is large and small.

b. !Your gift is round and square.

(40)a. This is both a pen and a knife.

b. The substance is a stimulant and an anti-inflammatory.

(41)a. Mary is a housewife and a doctor.

b. Bernstein was a composer and a conductor.

(42)a. This object is a knife and therefore a weapon.

b. Emanuel Ax is a pianist and therefore a musician.

(43) Emanuel Ax is a pianist and therefore a human.

(44) a. very old gold

- b. a new tree
- c. a young tiger
- d. such a beautiful flower

- (45) a. a blue/Swiss pen
- b. a bright/expensive bulb
 - c. a long/shiny CD

- (46) a. a very old friend
- b. a good professor
 - c. such a beautiful dancer

- (47) a. Mary enjoyed drinking her beer.
- b. Mary enjoyed her beer.

- (48) a. John began to write his thesis.

- b. John began writing his thesis.
- c. John began his thesis.

- (49) a. !John finished the tree.
b. !Mary began a tiger.

Unaccusatives and Selectional Specificity

(50) **Externally Caused Events:** break, etc.

- a. The vase broke.
- b. Mary broke the vase.
- c. The storm broke the window.

(51) **Internally Caused Events:** decay, bloom, etc.

- a. The flowers bloomed early.
- b. *The gardener bloomed the flowers.

Verbal Polysemy Data

Fillmore (1985), Levin and Rappaport (1998),
Jackendoff (1990), Pustejovsky (1995)

- (52) a. Mary began the book.
b. Mary began reading the book.
c. Mary began to read the book.
- (53) a. Mary finished her coffee.
b. Mary finished drinking her coffee.
- (54) a. John enjoyed the movie.
b. John enjoyed watching the movie.

- (55) a. The woman baked a potato in the oven.
b. The woman baked a cake in the oven.

- (56) a. John swept.
b. John swept the floor.
c. John swept the dirt into the corner.
d. John swept the dirt off the sidewalk.
e. John swept the floor clean.
f. John swept the dirt into a pile.

shovel, rake, shave, weed.

- (57) a. John whistled.
b. John whistled at the dog.
c. John whistled a tune.
d. John whistled a warning.

e. John whistled her appreciation.

f. John whistled to the dog to come.

yell, snap, whisper.

What do Prepositions Select?

during, on, before, after, at.

$$\begin{bmatrix} p \\ i \end{bmatrix} \rightarrow (e \rightarrow t)$$

- (58) a. John arrived during the lecture.
b. The lecture was in the afternoon.
c. John arrived in the afternoon.

- (59) a. Mary left work at 5:00 pm.
b. Mary's party is at 5:00 pm.
c. *Mary left work at her party.

Polysemy of *at*

(60)a. John is swinging **at** the ball.

b. Mary ate **at** noon/midnight.

c. Mary is **at** peace with her decision.

d. We were **at** war with Iraq.

(61)a. The temperature is **at** 70 degrees.

b. John's weight is holding **at** 200 pounds.

c. Shares opened **at** \$34.00.

Locative Data

(62)a. Mary is **at** the blackboard.

b. Mary is standing/writing/ **at** the blackboard.

c. Mary is **near** the blackboard.

(63)a. Jane is **at** her desk.

b. Jane is working/sleeping **at** her desk.

c. Jane is **near/on/under** her desk.

(64)a. Zac is **in/at** school today.

b. Zac's mother is **in/at** the school today.

Adjectival Selection

Adjectives modify specific aspects of the head Noun:

- (65) a. a former professor
b. my former car
c. the retired admiral
- (66) a. the escaped prisoner
b. an unbaked cake
- (67) a. the vacation/well-built house
b. a fast/young typist
c. some bright/expensive bulbs
d. a long/scratched record/CD.

- (68) a. a blue pen
b. the stone lion
c. the toy gun

Selecting for Change

(69)a. Mary broke the glass.

b. John built a house.

c. The child ate a cookie.

(70)a. The father comforted the crying child.

b. The woman on the boat jumped into the water.

c. Mary rescued the drowning man.

- (71)a. Mary repaired every leaky faucet in the house.
- b. John mixed the powdered milk into the water.
- c. Nicholas fixed the flat.

Event Persistence Structure

(72) **DISPLACED TEMPORAL REFERENCE**

- a. The President was born in 1946.
- b. Tom met his wife in 1988.
- c. All rich men were obnoxious children.

Tracking Descriptions in Discourse

(73)a. John escaped from the police.

b. The man escaped from the police.

c. The prisoner escaped from the police.

(74) *passenger, pedestrian. victim*

(75) **DISCOURSE EPITHETS**

a. Five prisoners have escaped from Huntsville Prison.

b. [...] The escaped prisoners are hiding out in the woods around Crawford.

(76) The audience_{*i*} left the music hall.

(77)a. *It_{*i*} then went home.

b. They_{*i*} then went home.

c. It_{*i*}/They_{*i*} had just heard Bernard Haitink's last performance.

Coherent Event Descriptions

(78)a. John comforted the crying child.

b. Cathie mended the torn dress.

(79)a. The plumber fixed every leaky faucet.

b. The plumber fixed every blue faucet.

(80)a. !Mary cleaned the clean table.

b. !John built the built house.

c. !John drank the empty glass of milk.

Selectional Origin of Agency

(81) a. John killed the flowers accidentally/intentionally.

b. John/the rock rolled down the hill.

c. John cooled off with an iced latte.

(82) a. John gave Mary a book.

b. John gave Mary a shower.

c. John gave the plants a spray.

- (55) a. The woman baked a potato in the oven.
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